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FISH RESEARCH PROJECT OREGON

ASPECTS OF LIFE HISTORY AND PRODUCTION OF JUVENILE ONCORHYNCHUS MYKISS IN THE GRANDE RONDE RIVER BASIN, NORTHEAST OREGON

Summary Report

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FISH RESEARCH PROJECT
OREGON

ASPECTS OF LIFE HISTORY AND PRODUCTION OF JUVENILE *Oncorhynchus mykiss* IN THE GRANDE RONDE RIVER BASIN, NORTHEAST OREGON

SUMMARY REPORT

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ABSTRACT

Rotary screw traps, located at four sites in the Grande Ronde River basin, were used to characterize aspects of early life history exhibited by juvenile *Onchorhychus mykiss* during migration years 1995-99. The Lostine, Catherine Creek and upper Grande Ronde traps captured fish as they migrated out of spawning areas into valley rearing habitats. The Grande Ronde Valley trap captured fish as they left valley habitats downstream of Catherine Creek and upper Grande Ronde River rearing habitats.

Dispersal downstream of spawning areas was most evident in fall and spring, but movement occurred during all seasons that the traps were fished. Seaward migration occurred primarily in spring when *O. mykiss* smolts left overwintering area located in both spawning area and valley habitats. Migration patterns exhibited by *O. mykiss* suggest that Grande Ronde Valley habitats are used for overwintering and should be considered critical rearing habitat.

We were unable to positively differentiate anadromous and resident forms of *O. mykiss* in the Grande Ronde River basin because both forms occur in our study area. The Grande Ronde Valley trap provided the best information on steelhead production in the basin because it fished below valley habitats where *O. mykiss* overwinter.

Length frequency histograms of *O. mykiss* captured below upper spawning and rearing habitats showed a bimodal distribution regardless of the season of capture. Scale analyses suggested that each mode represents a different brood year. Length frequency histograms of *O. mykiss* captured in the Grande Ronde Valley trap were not bimodal, and primarily represented a size range consistent with other researchers' accounts of anadromous smolts.

INTRODUCTION

Salmonid populations in the Grande Ronde River basin have declined over the past 50 years. Recent estimates of anadromous forms of naturally produced *Oncorhynchus mykiss* (steelhead) returns are an order of magnitude lower than in the past (Busby et al. 1996). Concern over the decline of steelhead in the Pacific Northwest and California led to the 1994 petition requesting a status review under the Federal Endangered Species Act (ESA). In August 1997 the National Marine Fisheries Service listed stream maturing types of steelhead as threatened under federal ESA. Steelhead originating from the Snake River Basin, including the Grande Ronde River steelhead, are considered one evolutionarily significant unit. Resident forms of *O. mykiss* from the Snake River basin were not listed.

Among salmonids, *O. mykiss* has one of the most diverse life history strategies, maintaining both anadromous and resident forms in nature. Anadromous forms of *O. mykiss* (steelhead) typically migrate from freshwater, mature in a marine environment, and then return to spawn in freshwater. Whereas the majority of steelhead spend two winters in fresh water before smolting and migrating to the ocean, some may spend seven years or more in fresh water (Busby et al. 1996). Steelhead may also spend from one to seven years in the ocean before returning to their natal stream to spawn (Busby et al. 1996). Maturation in steelhead occurs in the ocean (ocean-type) and in streams (stream-type), and a small proportion of both ocean and stream types spawn multiple times (Scott and Crossman 1985, Behnke 1992, Lindsay et al. 1991, Lindsay et al. 1992).

Resident forms of *O. mykiss* (rainbow trout: coastal variety or redband trout: inland variety) spend their entire life in a freshwater environment. Rainbow trout become sexually mature as early as one year of age in males, but usually achieve sexual maturity at three to seven years of age (Scott and Crossman 1985). Maturation in rainbow trout occurs in freshwater, and these fish are able to spawn multiple times (Scott and Crossman 1985, Schroeder and Smith 1989, Behnke 1992). Although rainbow trout have been reported to spawn in the fall, most of these fish spawn in the spring of the year (Scott and Crossman 1985, Behnke 1992).

It is difficult to distinguish anadromous and resident forms of *O. mykiss* when they co-occur. These fish are usually indistinguishable at the juvenile stage, and remain visually similar until steelhead undergo smoltification and adopt the silvery appearance of an ocean going fish. Genetic differentiation has shown some success in distinguishing these two forms (Allendorf 1975, Utter and Allendorf 1977, Okazaki 1984, Schreck et al. 1986, Reisenbichler et al. 1992). Although, Currens et al. (1987) examined the genetic difference between rainbow trout and steelhead from the North and South Forks of the John Day River, Oregon and found that differences between *O. mykiss* in the North and South Forks were larger than the differences between presumed rainbow trout and steelhead from the South Fork John Day River. Currens et al. findings were reinforced by Leider et al. (1995) who found that some steelhead and rainbow trout may not be reproductively isolated, and concluded that naturally produced rainbow trout were visually indistinguishable from steelhead.

In this report we begin to characterize aspects of life history and production of juvenile *O. mykiss* from the Grande Ronde River. The Grande Ronde River originates in the northeast corner of Oregon and flows through the southeast corner of Washington where it joins the Snake River. The Grande Ronde River supports both resident and anadromous forms of *O. mykiss* which have been observed on spawning grounds in spring. Rotary screw traps operated since 1994 by the Oregon Department of Fish and Wildlife Spring Chinook Early Life History Study have captured what appear to be resident and anadromous forms of juvenile *O. mykiss* as they moved past four trapping sites in the Grande Ronde River basin (Figure 1).

The three primary objectives addressed in this report are: 1) document annual downstream migration timing of steelhead in the Grande Ronde River basin, 2) estimate the number of fish moving downstream by season for each trapping location, and 3) present information on size at capture to identify age distribution by season.

METHODS

We used rotary screw traps to capture fish as they moved downstream from juvenile rearing areas. Rotary screw traps with a cone diameter of 1.5 m were fished downstream of primary spawning and rearing habitats in Catherine Creek (rkm 32), and the Lostine (rkm 3) and upper Grande Ronde rivers (rkm 299). We also fished a rotary screw trap on the Grande Ronde

River near the downstream end of the Grande Ronde Valley (rkm 164) to capture fish as they left the valley habitat. A 1.5 m diameter rotary screw trap was fished at the Grande Ronde Valley site during the fall and winter seasons, and was replaced with a 2.4 m diameter rotary screw trap when water depths were sufficient in spring. All of these traps were equipped with live-boxes that were large enough to safely hold hundreds of fish for up to 72 hours.

In calculating abundance estimates from data collected at the Lostine River, Catherine Creek, and upper Grande Ronde River traps, we assumed all fish that passed the traps were making directed, downstream movements (i.e., were migrants). Violation of this assumption by non-migrating fish moving within the area near the traps would result in positively biased abundance estimates. We do not know if, or to what extent, our estimates were biased in this manner. However, based on patterns of movement we think most fish that passed the trap were migrants. Because of the proximity of the spawning and rearing habitats and the tendency for *O. mykiss* juveniles to move about in freshwater, estimates of *O. mykiss* for these traps may include resident and anadromous forms of *O. mykiss*.

We typically checked our traps daily. Occasionally during the summer and winter seasons, when the daily trap catch was consistently low (<5 fish) and water temperatures were not high, we checked our traps every second or third day. We removed fish from each live-box, and enumerated the trap catch by species for each trapping period. Fish were anesthetized prior to sampling using a 60 mg/L solution of MS-222. Length and weight were measured from up to 20 fish each weekday, and scale samples were taken in the fall of 1996 for age determination. Injured or previously marked fish were released downstream. Fish were handled as quickly as possible, and were allowed to revive to an upright swimming position before being released back into the river. We collected water temperatures using hand-held thermometers and computerized thermographs stationed at each trap site. River height was recorded using permanent stream gauges each time a trap was checked.

We conducted seasonal trap efficiency tests at each trap site by marking up to 20 fish each weekday throughout a given season. Fish were marked using a Panjet™ marking instrument (Hart and Pitcher 1969) that applied a non-toxic acrylic paint mark just under the skin of a fish.

Once marked, fish were released upstream of the trap at a distance adequate for fish to redistribute throughout the water column (one or two river bends upstream of trapping site). Fish recaptured in the trap with a paint mark were enumerated and released downstream. We estimated seasonal trapping efficiency (E) by dividing seasonal recaptures (R) by the number of marked fish released (M) upstream of the trap during the season ($E = R/M$).

We were unable to estimate the number of *O. mykiss* that passed our traps prior to the 1997 migration year (MY 97) because trap efficiency tests were not conducted using *O. mykiss*. During the summer and winter when our trapping operations were interrupted or recaptures were too few we were unable to estimate the number of *O. mykiss*. Therefore, only trap catch data were described for these seasons (Appendix A).

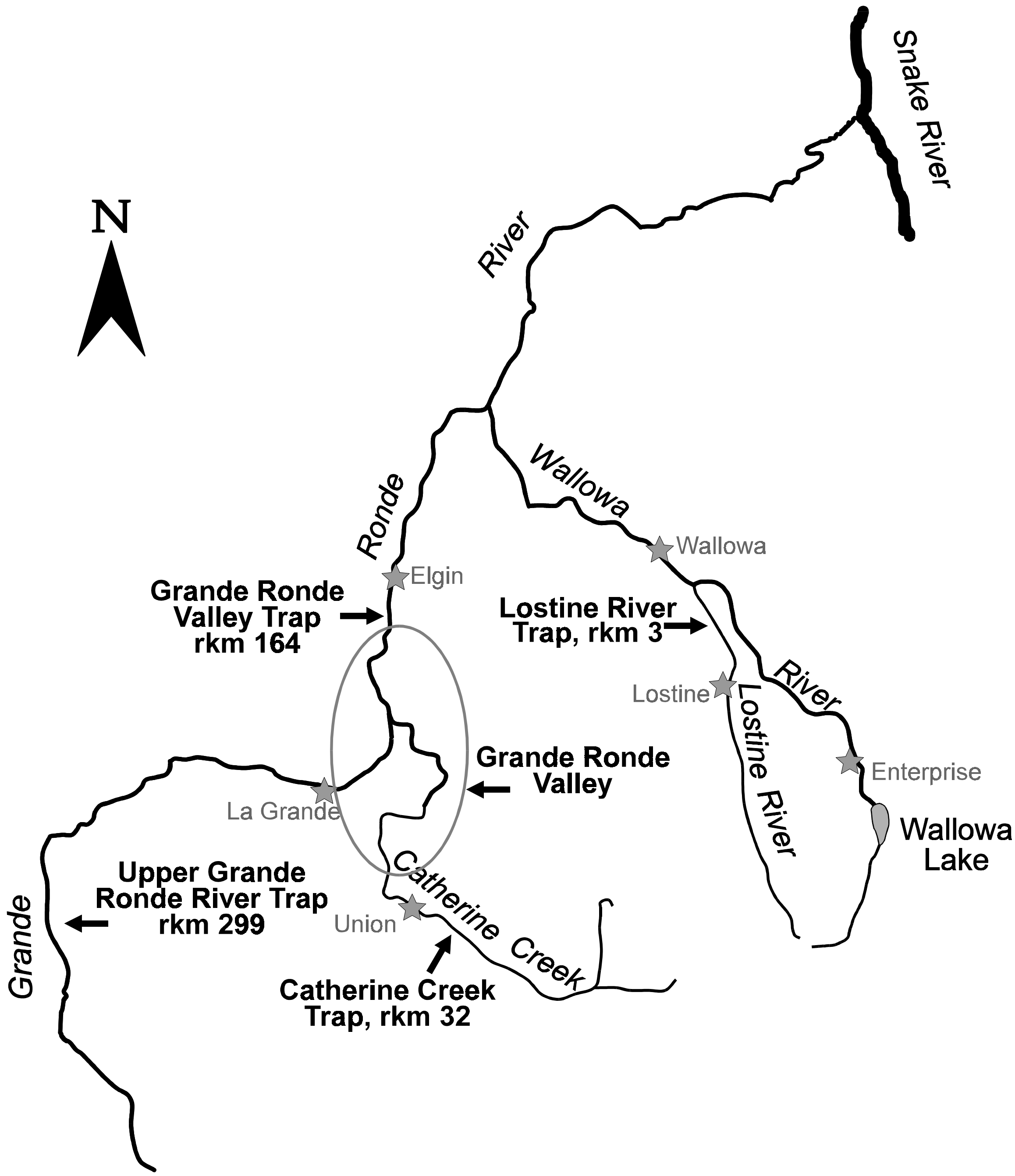

Figure 1. Locations of the four trapping sites in the Grande Ronde River basin. The Grande Ronde Valley is circled.

A migration year (MY) for summer steelhead overlaps two calendar years, and begins July 2 and ends July 1 of the following year (based on a Julian calendar: Appendix B). Seasonal breaks were determined by identifying trends in environmental changes and fishing activities. Our traps were typically not fished during the summer season (weeks 27-34) because of high river temperatures and low flows. The fall season usually began in the last week in August when river temperatures decreased and flows allowed for continuous trapping activities, and ended when the river iced-up (weeks 35-48). The winter season was the period when our traps were interrupted by icing events (weeks 49-8), and spring began at ice-out and ended when the river developed summer characteristics (weeks 9-26).

Migration timing was summarized weekly for each trapping site using a Julian calendar (Appendix B). We estimated the number of migrants (*N*) that passed each trapping site using the total number of fish captured (*C*) during the season divided by the estimated trapping efficiency (*E*) for the season ($N = C/E$). Variance estimates for each seasonal estimate were calculated using the Bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. We used the variance (*V*) determined by the Bootstrap method to calculate confidence intervals for each estimate using the equation: $95\%CI = 1.96 \sqrt{V}$. Trap catch trends for periods when trap efficiency estimates were not available probably do not reflect actual migration past our traps, and are at best minimum numbers of fish passing our traps.

When trap efficiency data were available we estimated the number of *O. mykiss* that passed our traps by season for MY 97, 98 and 99. We did not conduct trapping efficiency tests using *O. mykiss* during MY 94 through 96 at any of our trapping sites. We were not able to estimate the number of fish that moved past our traps in the summer at any trap. We did not estimate migrants for seasons when more than one of the following occurred: 1) less than 10 fish were recaptured, 2) the minimum estimate was less than the number of unmarked fish caught during the season, 3) a positive bias percentage was calculated by the bootstrap method, or 4) at least 1 of 1,000 iterations was $E^* = 0$.

Frequency histograms were generated from length data to estimate the age distribution of fish moving past individual trapping sites. We attempted to collect up to 100 lengths and weights each week at each trapping site. Fish were selected haphazardly at all trap sites in all years except the Grande Ronde Valley trap in MY 97 when all fish less than 145mm were sampled. Therefore, length data presented for MY 97 is biased for fish less than 145mm. In addition, scales from fish captured during the fall of MY 96 were analyzed using a microfiche reader to identify the presence of winter annuli (Borgerson and Bowden 1997). This analysis did not represent all of the different sized fish that we caught in our traps because scales were not collected from fish greater than 200 mm. Preliminary statistics on age for a given season were compared when the data was available. We were not able to visually differentiate naturally produced resident and anadromous forms of *O. mykiss* in these traps, so it is possible that a portion of these fish are rainbow trout.

RESULTS AND DISCUSSION

Time of Movement

Lostine River Trap

The Lostine River trap (rkm 3) was fished during MY 97 through MY 99. In MY 97 we deployed the Lostine River trap on October 25, 1996, and continued fishing it until July 1, 1997 (Figure 2). The trap was not fished during the summer and early fall seasons in MY 97. We observed fluctuations in catch during the late fall, winter, and spring seasons. Late fall movement peaked in week 47, but increased movement typically only lasted short periods (two to three days). A peak in movement during winter occurred in week 1, but generally fewer than 80 fish moved past the trap each week. The majority of downstream movement in MY 97 occurred in spring. The largest weekly peak also occurred in spring (week 17). During spring, downstream movement was estimated to have exceeded 350 fish for four successive weeks (16 through 19).

Trapping activities during MY 98 occurred from July 2, 1997 through July 1, 1998 (Figure 2). We were unable to accurately estimate the number of migrants moving past the trap in the summer and winter seasons. Peaks in movement were observed in fall and spring, but unlike MY 97 a majority of the fish in MY 98 moved downstream in fall. In fall our estimate of migrants peaked in week 44, and a period of sustained movement was evident from week 37 through 41. The largest weekly peak was observed in spring during week 17, but there was no sustained period of movement.

Trapping activities during MY 99 occurred from July 2, 1998 through June 30, 1999 (Figure 2). We were unable to accurately estimate the number of migrants moving past the trap in summer. Peaks in movement were observed in fall, winter, and spring. A majority of the fish in MY 99 moved downstream in fall. The largest weekly peak also occurred in fall during week 40. A peak in movement during winter occurred in week 52, and we estimated that greater than 100 fish moved past the trap during week 49 through 1. In spring our estimate of migrants peaked in week 16, and a period of sustained movement was evident from week 16 through 21.

Catherine Creek Trap

We fished the Catherine Creek trap (rkm 32) during the MY 95 through MY 99. The peak downstream movement for individual years varied between the fall, winter, and spring seasons of different migration years. As discussed earlier we were unable to estimate the magnitude of the seasonal variation in movement past the trap for MY 95 and MY 96.

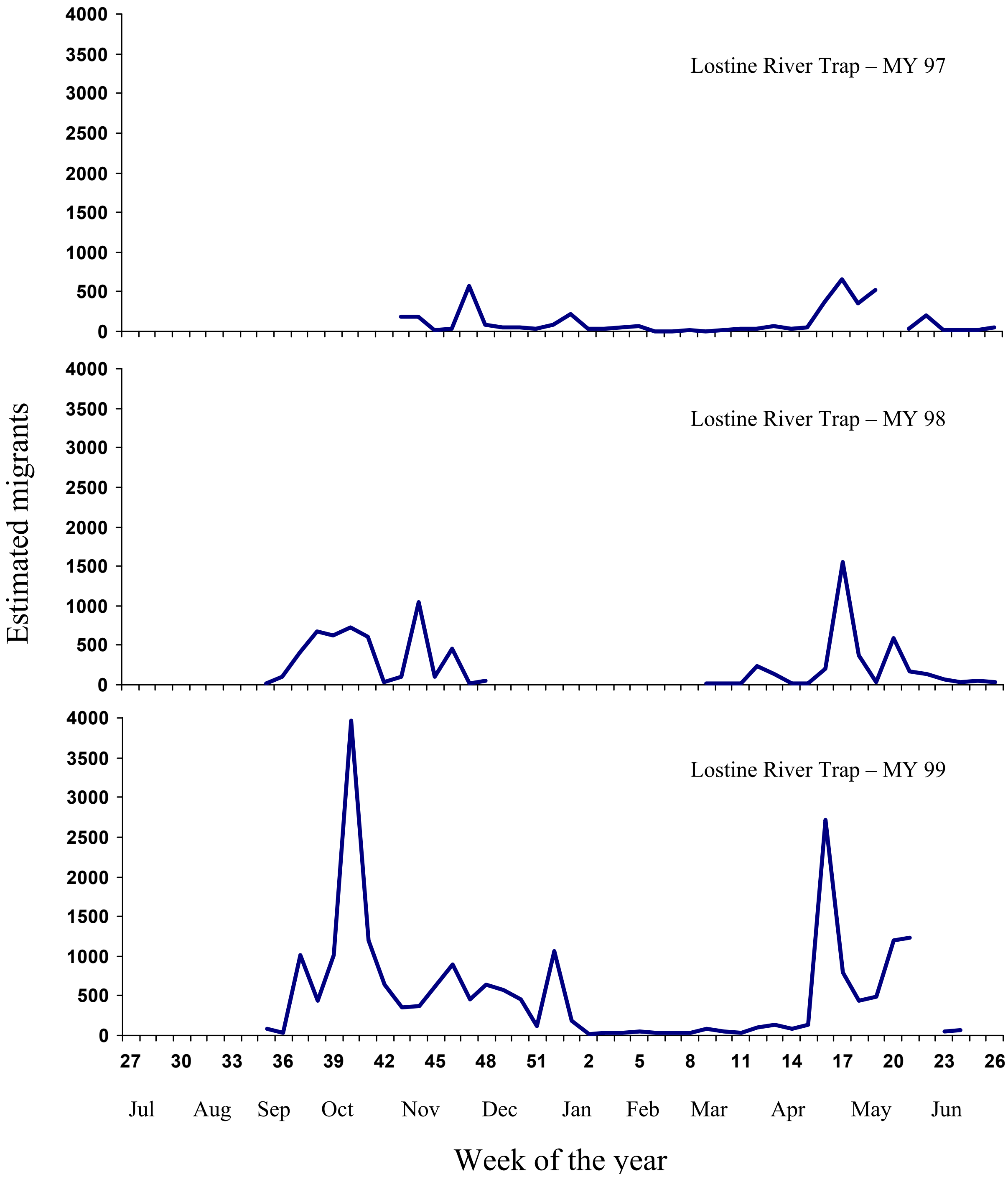

Figure 2. Time of movement of *O. mykiss* past the Lostine River trap (rkm 3) for migration years (MY) 1997 through 1999. Periods when the trap was not fished for the entire week of the year are represented by a blank space.

During MY 96 we fished the trap from July 2 through December 23, 1995 and February 15 through June 3, 1996 (Appendix A-1). Summer movement peaked in week 33, and continued through week 35. Fall catch peaked in week 42, and exceeded 50 fish from weeks 39 through 43. We did not fish the trap during most of the winter, but did catch between 21 and 57 fish per week during the four weeks that the trap was fished. The majority of downstream movement in MY 96 occurred in spring. The largest weekly peak occurred in spring in week 19. Spring catch exceeded 50 fish from week 10 through 19.

During MY 97 the Catherine Creek trap operated from September 26, 1996 through June 26, 1997 with a minor halt in trapping activities occurring from December 17, 1996 to January 2, 1997 when an icing event occurred (Figure 3). As in past years there were no consistent trends in peak seasonal movement, and fish were present during all seasons the trap was fished. The trap was not fished during summer of MY 97. Fall migrants peaked in week 47, and we estimated that more than 350 fish passed this trap each week from week 41 through 44. The largest weekly peak during MY 97 occurred during winter in week 1. We also estimated that greater than 50 fish moved past this trap during week 50 and 2. This winter movement was associated with an unexpected warming event. The majority of downstream movement in MY 97 occurred in spring. Spring movement peaked in week 18, and our weekly estimate exceeded 375 fish in 13 of 19 weeks the trap was fished.

In MY 98 we fished our trap from July 25 through December 2, 1997 and from January 6 through July 1, 1998 (Figure 3). Again fish moved past the trap during all seasons that the trap was fished. We captured fish in the summer season, but were unable to estimate the number of migrants passing by the trap. Fall migrants peaked in week 43 with 1,692 fish estimated passing by the trap, and we estimated more than 300 migrants in 5 of 15 weeks that the trap was fished. We did not observe a peak in winter, but fish were present every week the trap was fished. The majority of downstream movement in MY 98 occurred in spring. The largest weekly peak in spring occurred in week 13. We estimated more than 300 migrants passed by the trap in 11 of 18 weeks during spring season.

In MY 99 we fished our trap from July 1 through December 31, 1998 and from January 12 through July 1, 1999 (Figure 3). Again fish moved past the trap during all seasons that the trap was fished. We captured fish in the summer season, but were unable to estimate the number of migrants passing by the trap. Fall migrants peaked in week 45 with 4,810 fish estimated passing by the trap, and we estimated more than 200 migrants in 10 of 14 weeks that the trap was fished. We did not observe a peak in winter, but fish were present every week the trap was fished. The majority of downstream movement in MY 99 occurred in spring. The largest weekly peak in spring occurred in week 12. We estimated more than 300 migrants passing by the trap in 12 of 18 weeks during spring season.

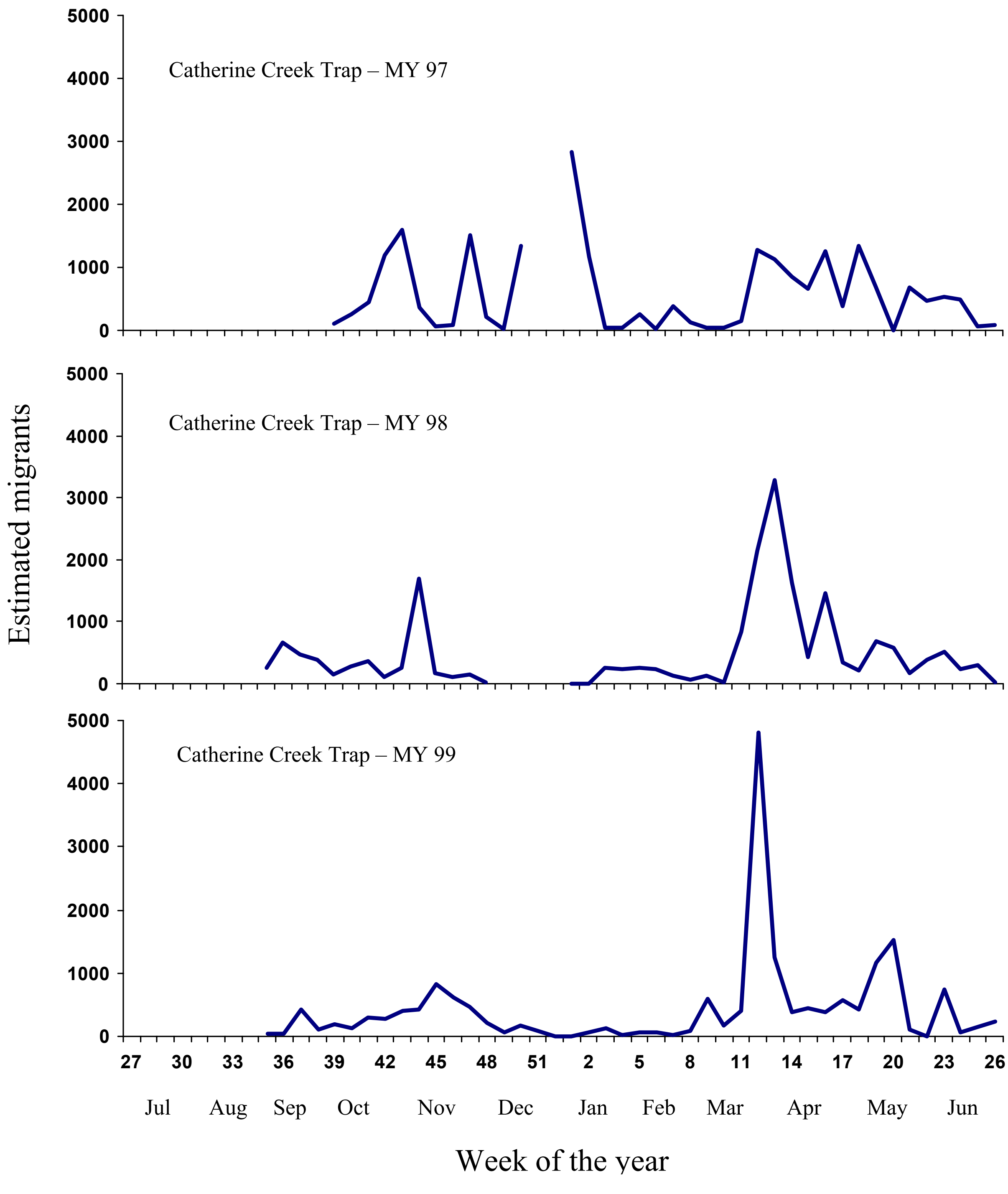

Figure 3. Time of movement of *O. mykiss* past the Catherine Creek trap (rkm 32) for migration years (MY) 1997 through 1999. Periods when the trap was not fished for the entire week of the year are represented by a blank space.

Upper Grande Ronde River Trap

We fished the Upper Grande Ronde River trap in MY 94, and MY 96 through MY 99. Fish primarily moved past the trap in spring following ice out. Trapping efficiency tests were not conducted during MY 94 and 96, so we were unable to estimate the number of fish passing the trap. Fish were present whenever the trap was fished with the exception of weeks 42 through 44 of the MY 96, week 34 of MY 97, week 46 and 9 of MY 98, and week 33 and 10 of MY 99.

During MY 94 the Upper Grande Ronde River trap fished from September 3 through November 17, 1993, and from March 9 through July 1, 1994 (Appendix A-2). We did not fish the trap during the summer or winter seasons. Fall catch peaked in week 41, but fewer than 50 fish were caught in the trap in all 9 weeks that the trap was fished. The majority of downstream movement in MY 94 occurred in spring. We observed the largest weekly peak catch in spring during week 16, and spring catch exceeded 100 fish in 11 of 18 weeks that the trap was fished.

In MY 96 the Upper Grande Ronde River trap fished from July 21 through October 31, 1995, and from March 9 through July 1, 1996 (Appendix A-2). Summer catch peaked in week 32, but did not exceed 26 fish in any given week. Fall catch peaked in week 40, but fewer than 10 fish were captured in the trap during all other weeks that the trap fished. We were able to fish the trap the last two weeks of the winter season in MY 96. Winter catch exceeded 50 fish during this period. The majority of downstream movement in MY 96 occurred in spring. We also observed the largest weekly peak catch in spring during week 19, and spring catch exceeded 50 fish in 10 of 18 weeks that the trap was fished.

During MY 97 the Upper Grande Ronde trap was fished during summer from July 2 through July 17, 1996 and August 7 through August 22, 1996. The trap was re-deployed in fall and fished from September 19 through December 2, 1996 when it iced-up. We began fishing the trap again February 27, 1997 and fished until July 1, 1997 (Figure 4). Summer trap catch was not accompanied by trap efficiency tests, so we were not able to estimate the number of migrants moving past the trap. Catch during summer ranged from 0 to 23 fish per week. Fall showed two peaks in movement in week 43 and week 47. Generally our weekly estimate did not exceed 100 fish moving past the trap during fall. The trap was not fished in winter. The majority of downstream movement in MY 97 occurred in spring. Again the largest weekly peak occurred in spring (week 12). Estimates of spring migrants exceeded 300 fish in 11 of 18 weeks the trap was fished.

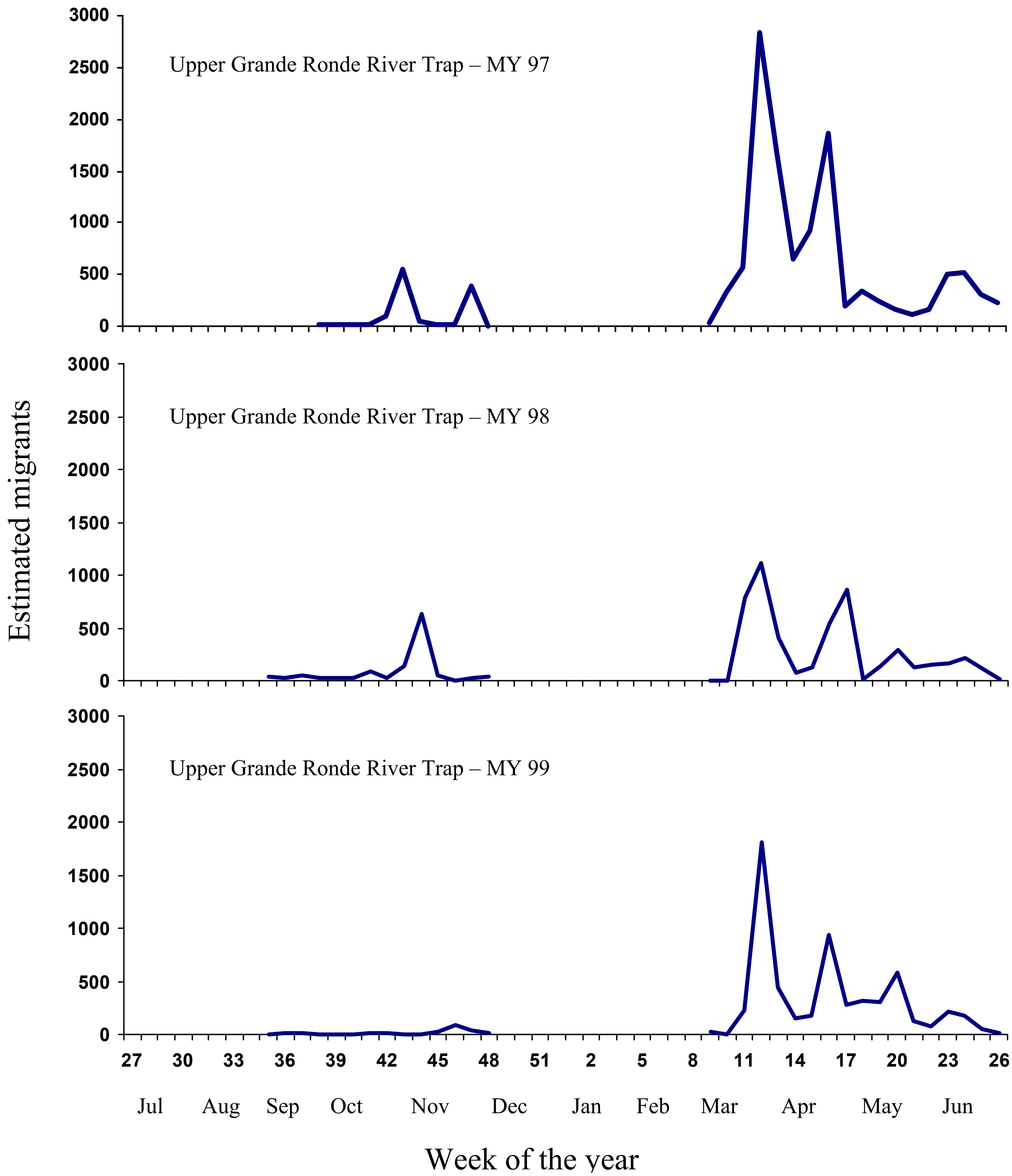

Figure 4. Time of movement of *O. mykiss* past the Upper Grande Ronde River trap (rkm 199) for migration years (MY) 1997 through 1999. Periods when the trap was not fished for the entire week of the year are represented by a blank space.

In MY 98 we fished the Upper Grande Ronde River trap from July 2 through December 2, 1997 and February 9 through July 1, 1998 (Figure 4). Although we did conduct trapping efficiency tests in the summer of MY 98 recoveries were not sufficient to accurately estimate the number of fish moving past the trap. Catch patterns during the summer season of 1998 were similar to the 1996 and 1997 patterns. Movement during fall peaked in week 44, but we estimated that fewer than 50 fish moved past the trap in 11 of 14 weeks. We fished the trap during the last three weeks of the winter season, and caught fewer than 5 fish per week. We did not catch enough fish to estimate trapping efficiency. The majority of downstream movement in MY 98 occurred in spring. The largest weekly peak also occurred in spring in week 12, and estimates exceeded 100 fish in 13 of 18 weeks.

In MY 99 we fished the Upper Grande Ronde River trap from July 2 through December 6, 1998 and February 19 through July 1, 1999 (Figure 4). We did not conduct trapping efficiency tests in the summer of MY 99. Catch patterns during the summer season of 1999 were similar to the 1996, 1997 and 1998 patterns. Movement during fall peaked in week 46, but we estimated that fewer than 50 fish moved past the trap in 13 of 14 weeks. We fished the trap during the first and last weeks of the winter season, and caught 6 fish. The majority of downstream movement in MY 99 occurred in spring. The largest weekly peak occurred in spring in week 12, and estimates exceeded 100 fish in 13 of 18 weeks.

Grande Ronde Valley Trap

We fished the Grande Ronde Valley trap just upstream of the town of Elgin (rkm 164) during MY 94 through 99. This trap was fished in this location for the purpose of identifying when migrating fish moved downstream of Grande Ronde Valley habitat, which we know is used by overwintering anadromous fishes (Jonasson, et al. 1996, Jonasson, et al. 1997). Trap catch data for those years show the peak time of movement past the trap was in spring, but fish were caught during all seasons that the trap was fish. Trapping efficiency tests for this trap were not conducted during MY 94 through MY 96, so we were not able to accurately estimate the number of migrants passing the trap during these migration years. We also were not able to accurately estimate the number of migrants passing the trap in MY 98 because we used a fish sorter during the peak migration period that diverted fish larger than 145mm back into the river.

In MY 94 we fished the Grande Ronde Valley 1.5 m diameter trap from October 8, 1993 through February 24, 1994, and the 2.4 m diameter trap was fished from February 25 through June 27, 1994 (Appendix A-3). Weekly catch during fall ranged from 4 to 204 fish, and from 4 to 55 fish during winter. The majority of migrants passed by the trap in spring, and catch peaked in week 19. Weekly catch during spring was more than 210 fish in 11 of 15 weeks that the trap was fished.

During MY 95 we fished the Grande Ronde Valley 1.5 m diameter trap from October 21, 1994 through February 3, 1995, and the 2.4 m diameter trap was fished from February 8 through July 1, 1995 (Appendix A-3). Weekly catch during fall ranged from 2 to 70 fish, and from 1 to 22 fish during winter. The majority of migrants passed by the trap in spring, and catch peaked in week 18. Spring weekly catch was more than 70 fish in 9 of 21 weeks that the trap was fished.

In MY 96 we fished the Grande Ronde Valley 1.5 m diameter trap from October 6, 1995 through January 10, 1996, and the 2.4 m diameter trap was fished from March 4 through June 16, 1996 (Appendix A-3). The majority of migrants passed by the trap in spring, and catch peaked in week 15. Weekly catch during fall ranged from 0 to 135 fish, and from 0 to 20 fish during winter. Spring weekly catch was more than 130 fish in 9 of 14 weeks that the trap was fished.

During MY 97 we fished the Grande Ronde Valley 1.5 m diameter trap from October 24, 1996 through January 30, 1997, and the 2.4 m diameter trap was fished from February 8 through June 12, 1997 (Figure 5). Weekly migrant estimates during fall ranged from 19 to 894, and from 0 to 931 in winter. Peak spring migration past the Grande Ronde Valley trap occurred in week 19, and we estimated that more than 1,800 migrants moved past the trap each week from week 14 to 21.

In MY 98 we fished our trap from week 39 through week 26 (Appendix A-3). Fall and winter trapping efficiency estimates were not extensive enough to accurately estimate the number of migrants passing by the trap during these seasons. Furthermore, we were not able to accurately count the number of migrants caught in the trap in spring because a sorter was being used to safely remove migrating spring chinook salmon from the catch while safely returning hatchery steelhead to the river during annual hatchery steelhead releases in the Grande Ronde River basin. Based on limited catch data MY 98 appeared to follow the same spring dominated catch trend that we saw in MY 94 through 96.

During MY 99 we fished the Grande Ronde Valley 1.5 m diameter trap from September 28, 1998 through January 21, 1999, and the 2.4 m diameter trap was fished from January 22 through July 1, 1999 (Figure 5). We only captured ten *O. mykiss* during the fall and winter season combined, so we did not estimate abundance for these seasons. Peak spring migration past the Grande Ronde Valley trap occurred in week 21, and we estimated that more than 1,600 migrants moved past the trap each week from week 14 through 21, 23, and 24.

Estimated Number of Migrants

In the Lostine River we estimated that a minimum of 4,167 migrants ± 707 moved past this trap during MY 97 (Table 1). We did not fish the Lostine River trap before October 25, 1996, so we may have underestimated the number of migrants in MY 97. Similarly, we were not able to completely characterize annual movement for MY 97. We estimated that a minimum of 8,570 migrants ± 2,377 moved past the Lostine River trap during MY 98 (Table 2). This year the majority of the fish moved in fall (58%) rather than spring (42%). We estimated that a minimum of 22,077 migrants ± 2,166 moved past the Lostine River trap during MY 99 (Table 3). As in MY 98, the majority of the fish passed the trap during fall (53%), while winter and spring estimates were 12% and 35% respectfully.

Catherine Creek estimates during MY 97 showed large proportions of fish moving during fall and winter seasons (Table 1). We estimated a minimum of 22,310 ± 4,567 fish moved past the trap in MY 97. Spring migrants made up 46% of the annual total with fall and winter movement representing 28% and 26% respectively. Movement past the trap during MY 98 showed a similar pattern to MY 97 (Table 2). We estimated a minimum of 19,059 ± 4,179 fish moved past the trap in MY 98. The seasonal distribution was 67% in spring, 27% in fall, and 6% in winter. In contrast to MY 97 and 98, very little movement was detected during winter of MY 99 (Table 3). We estimated a minimum of 19,683 ± 3,865 fish moved past the trap in MY 99. The seasonal distribution was 77% in spring, and 23% in fall.

Movement past the Upper Grande Ronde River trap occurred primarily in spring of MY 97 (Table 1), MY 98 (Table 2), and MY 99 (Table 3). We estimated that a minimum of 12,835 ± 2,257 fish moved past this trap during MY 97. The proportion of annual movement past the trap in spring was 91%, with 9% moving past the trap in fall. We estimated that a minimum of 6,125 ± 1,047 fish moved past the Upper Grande Ronde River trap during MY 98. The annual proportion of movement in MY 98 was 79% in spring and 21% in fall. We estimated that a minimum of 6,131 ± 3,865 fish moved past the Upper Grande Ronde River trap during MY 99. The annual proportion of movement in MY 99 was 96% in spring and 4% in fall.

We were only able to accurately estimate the number of migrants moving past the Grande Ronde Valley trap for MY 97 (Table 1), and MY 99 (Table 3). We estimated 44,938 ± 7,384 steelhead passed the Grande Ronde Valley trap in spring, and only 1,146 ± 523 passed in fall of MY 97. The proportion of estimated migrants was 98% in spring and only 2% in fall. The trap was fished in winter but we were not able to estimate the number of migrants. We did not generate estimates for MY 98 because we did not recover any marked fish in fall and winter, and sampling bias was introduced in spring. We estimated 47,281 ± 33,433 steelhead passed the Grande Ronde Valley trap in spring of MY 99. The trap was fished in fall and winter but we were not able to estimate the number of migrants.

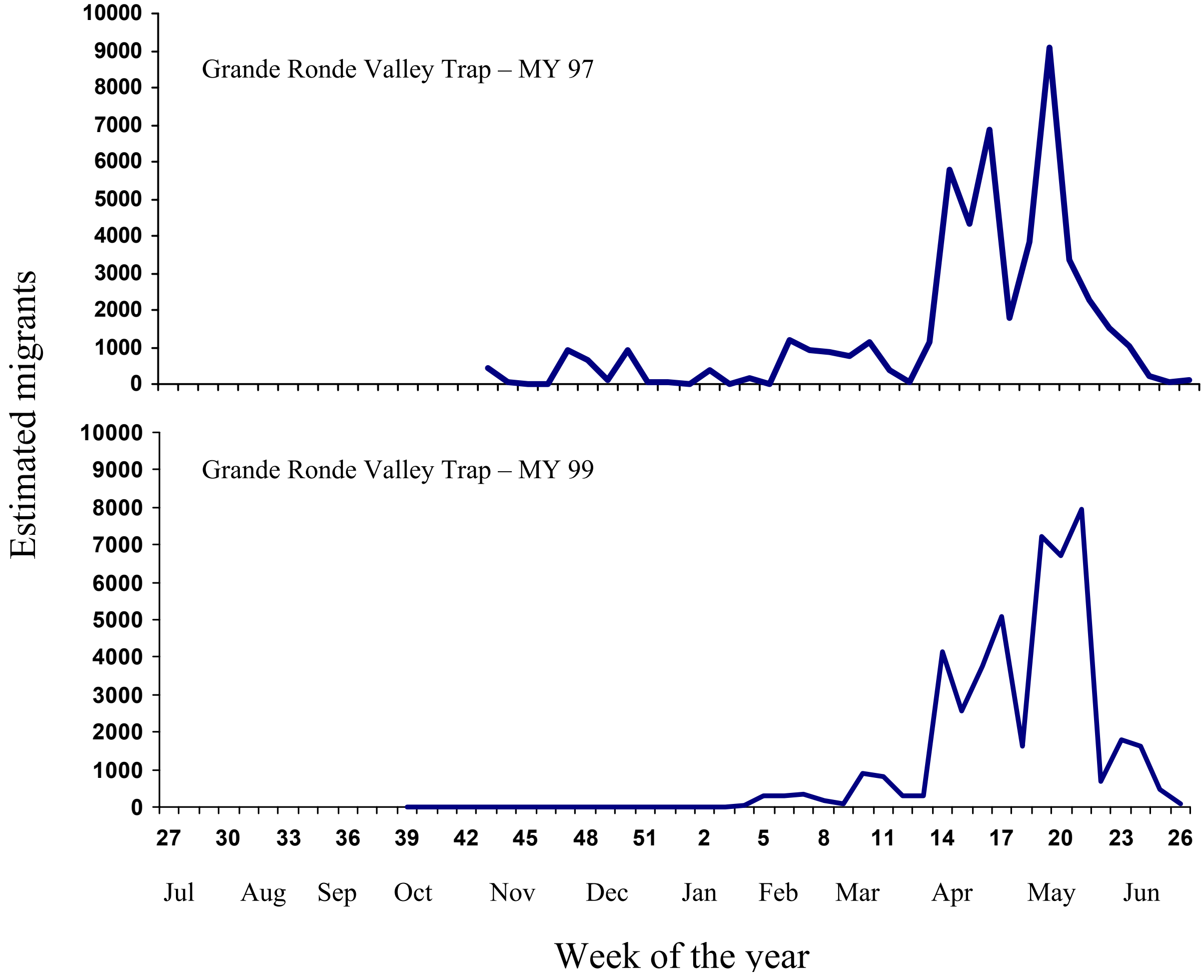

Figure 5. Time of movement of *O. mykiss* past the Grande Ronde Valley trap (rkm 164) for migration years (MY) 1997 and 1999. Periods when the trap was not fished for the entire week of the year are represented by a blank space.

Table 1. Estimated number of *O. mykiss* migrating past trapping locations on the Lostine and Grande Ronde rivers and Catherine Creek during MY 97.

Season	Trap efficiency	Number of migrants (95% CI)
	Lostine River (rkm 3)	
Fall	0.321	1,084 (± 299)
Winter	0.206	621 (± 379)
Spring	0.260	2,462 (± 517)
Combined		4,167 (± 707)
	Catherine Creek (rkm 32)	
Fall	0.116	5,836 (± 2,259)
Winter	0.094	6,245 (± 2,953)
Spring	0.096	10,229 (± 2,652)
Combined		22,310 (± 4,567)
	Upper Grande Ronde River (rkm 299)	
Fall	0.041	1,187 (± 228)
Spring	0.128	11,648 (± 2,245)
Combined		12,835 (± 2,257)
	Grande Ronde Valley (rkm 164)	
Fall	0.178	1,146 (± 523)
Spring	0.065	44,938 (± 7,384)
Combined		46,084 (± 7,402)

Table 2. Estimated number of *O. mykiss* migrating past trapping locations on the Lostine and Grande Ronde rivers and Catherine Creek during MY 98.

Season	Trap efficiency	Number of migrants (95% CI)
	Lostine River (rkm 3)	
Fall	0.105	5,010 (± 2,249)
Spring	0.216	3,560 (± 770)
Combined		8,570 (± 2,377)
	Catherine Creek (rkm 32)	
Fall	0.156	5,032 (± 1,189)
Winter	0.114	1,184 (± 827)
Spring	0.108	12,843 (± 3,921)
Combined		19,059 (± 4,179)
	Upper Grande Ronde River (rkm 299)	
Fall	0.208	1,317 (± 583)
Spring	0.276	4,808 (± 870)
Combined		6,125 (± 1,047)

Table 3. Estimated number of *O. mykiss* migrating past trapping locations on the Lostine and Grande Ronde rivers and Catherine Creek during MY 99.

Season	Trap efficiency	Number of migrants (95% CI)
	Lostine River (rkm 3)	
Fall	0.199	11,756 (± 1,660)
Winter	0.196	2,607 (± 698)
Spring	0.194	7,711 (± 1,202)
Combined		22,185 (± 2,166)
	Catherine Creek (rkm 32)	
Fall	0.194	4,467 (± 840)
Spring	0.116	15,216 (± 3,773)
Combined		19,683 (± 3,865)
	Upper Grande Ronde River (rkm 299)	
Fall	0.507	219 (± 60)
Spring	0.204	5,912 (± 1,155)
Combined		6,131 (± 1,157)
	Grande Ronde Valley (rkm 164)	
Spring	0.098	47,281(± 33,433)
Combined		47,281(± 33,433)

Size at Capture

Upper Spawning and Rearing Areas

In summary, length frequency histograms for *O. mykiss* moving past Catherine Creek, Lostine and Upper Grande Ronde River traps show a bimodal distribution during all seasons. We believe each mode represents a different cohort with the first mode being fish that had hatched the previous summer (age-0), and the second mode being fish that had been alive through one (1+) or more winters. Our samples were not necessarily randomly selected, so we did not estimate the distribution by age of fish that passed by the traps. The peak of the lower mode occurred between the 70 and 90 mm intervals regardless of the season and trapping location. Peaks in the upper mode ranged from the 120 to 190 mm intervals during fall, and between the 140 and 180 mm intervals in spring. The Lostine River fish peaked at a consistently larger size interval in the upper mode during spring than either Catherine Creek or the upper Grande Ronde River.

Length frequency histograms of fish captured in the Lostine River were summarized for all seasons the trap fished in MY 97 through MY 99. Fish collected in fall ranged from 35 to 268 mm with peaks in the lower and upper modes occurring in interval 70-90 and 150-190 (Figure 6). Length frequencies of fish collected in winter ranged from 58 to 340 mm with peaks in each mode occurring in interval 70-80 and 130. Length frequencies of fish collected in spring ranged from 51 to 390 mm with peaks in each mode occurring in interval 90-100 and 150-180 (Figure 6).

Catherine Creek data was summarized for all seasons the trap was fished in MY 95 through MY 99. Length frequencies of fish collected in fall range from 47 to 287 mm with peaks occurring in intervals 70-80 and 120-140 (Figure 7). Length frequencies of fish collected in winter ranged from 51 to 272 mm with peaks occurring in intervals 70-90 and 130-140. Length frequencies of fish collected in spring ranged from 39 to 319 mm with peaks occurring in intervals 70-90 and 140-150 (Figure 7).

Upper Grande Ronde River length frequency data was summarized for MY 94 through MY 99. Length frequencies from fish moving past the traps in fall ranged from 54 to 228 mm with peaks in each mode occurring in intervals 70-90 and 130 mm (Figure 8). Spring length frequencies ranged from 47 to 282 with peaks in each mode occurring in intervals 80-90 and 140-150 mm (Figure 8).

We analyzed juvenile *O. mykiss* scales collected from fish captured in fall of MY 97 at Catherine Creek and the Upper Grande Ronde River trap sites. Fish that had not been through their first winter (age-0) had a mean length of 72.3 mm with a range of 56 to 99 mm in Catherine Creek, and mean length of 93.0 mm with a range 85 to 102 mm in the upper Grande Ronde River. Fish that had been through one winter (1+) had a mean length of 142.4 mm with a range of 105 to 186 mm in Catherine Creek, and a mean of 135.0 mm with a range of 117 to 176 mm in the upper Grande Ronde River. These patterns were consistent with the peaks and range of the modes observed in fall season histograms for both of these trap sites, suggesting that each mode would represent fish of different ages. Scale analysis did not identify any fish that had lived through more than one winter.

Grande Ronde Valley

Length frequency histograms for *O. mykiss* captured in the Grande Ronde Valley trap from MY 95 through MY 97, and MY 99 generally revealed a single mode of distribution in fall, and spring (Figure 9). Lengths collected in spring also were clustered around the mean, and were negatively skewed (Figure 9). Length frequencies of fish collected in fall ranged from 55 to 281 mm with a peak in intervals 120-150 (Figure 9). Length frequencies of fish collected in spring ranged from 55 to 296 mm with a peak occurring in intervals 150-160 (Figure 9).

It is likely that most of the fish we captured in the Grande Ronde Valley trap are anadromous given the size and spring movement we have observed. Unfortunately, we did not collect any scales to verify the age distribution of naturally produced fish passing by the trap. The information we collected on size at the Grande Ronde Valley trap is consistent with Burgner et al. (1992) reporting that wild smolts throughout the Pacific rim ranged from 125 to 225 mm (mean around 160 mm) during seaward migration. Fish less than 125mm may be from tributaries that are close to the Grande Ronde Valley trap, and may be rearing in the area around the trap.

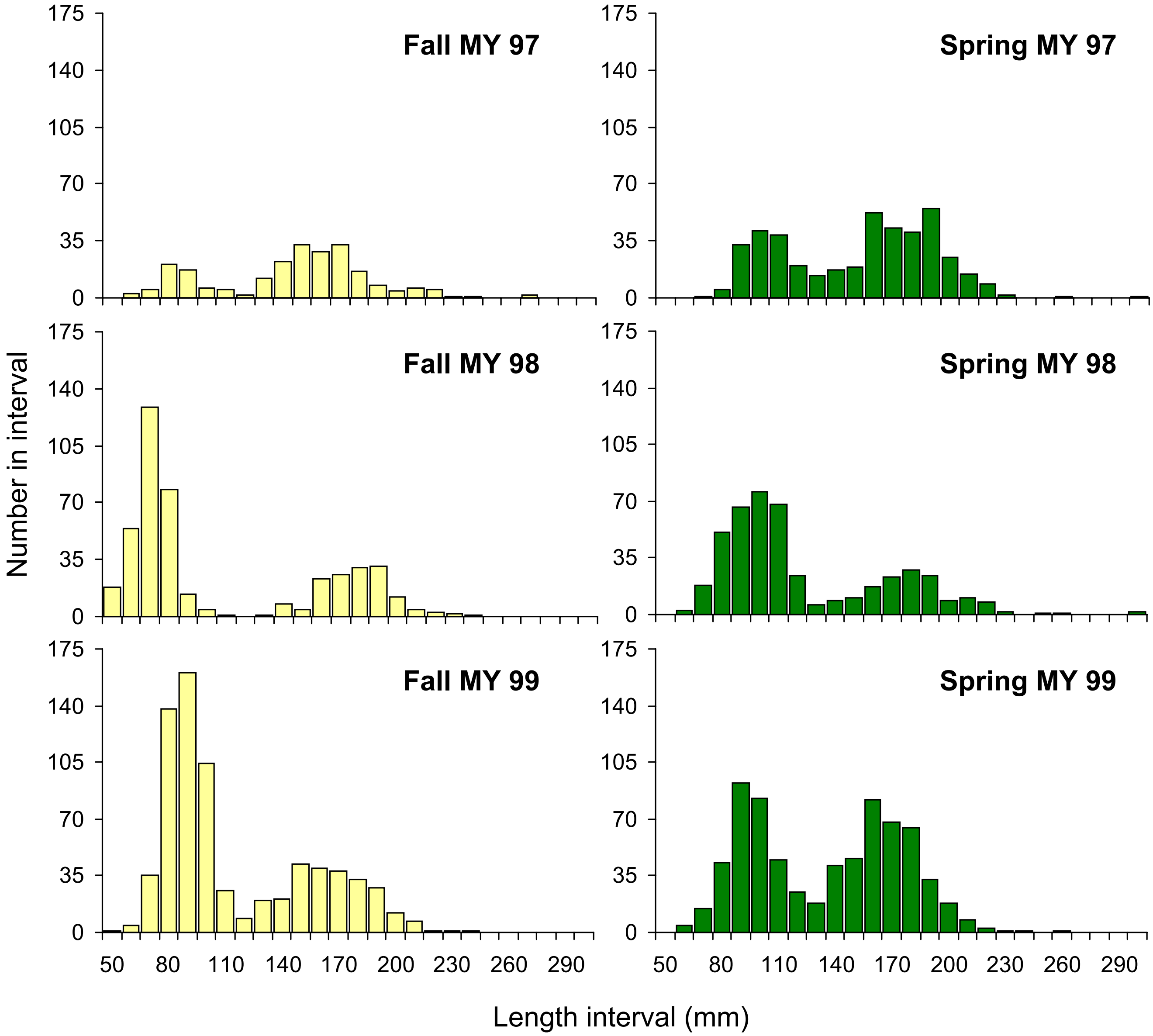

Figure 6. Length frequency distributions for *O. mykiss* captured at the Lostine River trap (rkm 3) by migration year.

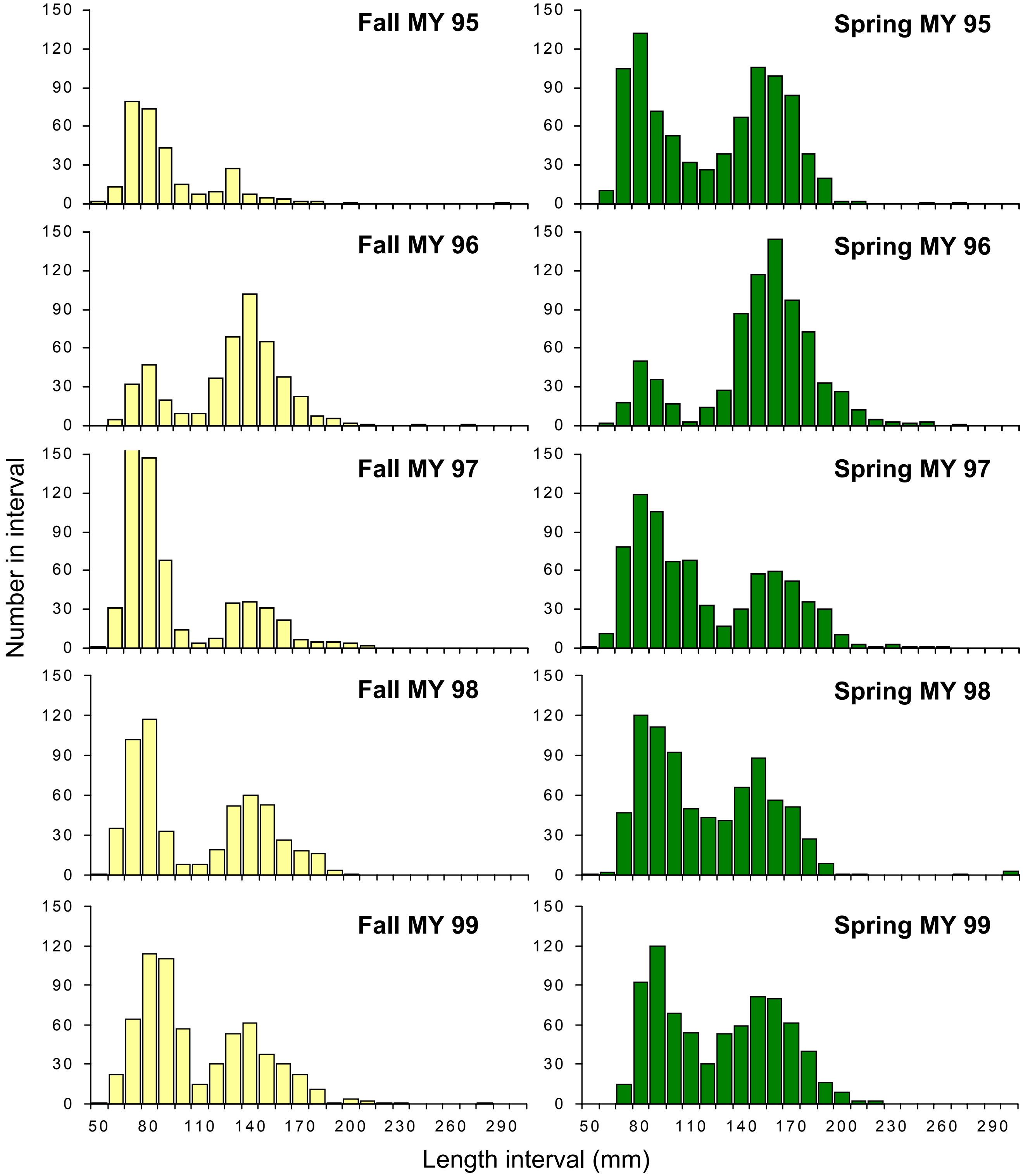

Figure 7. Length frequency distributions for *O. mykiss* captured at the Catherine Creek trap (rkm 32) by migration year.

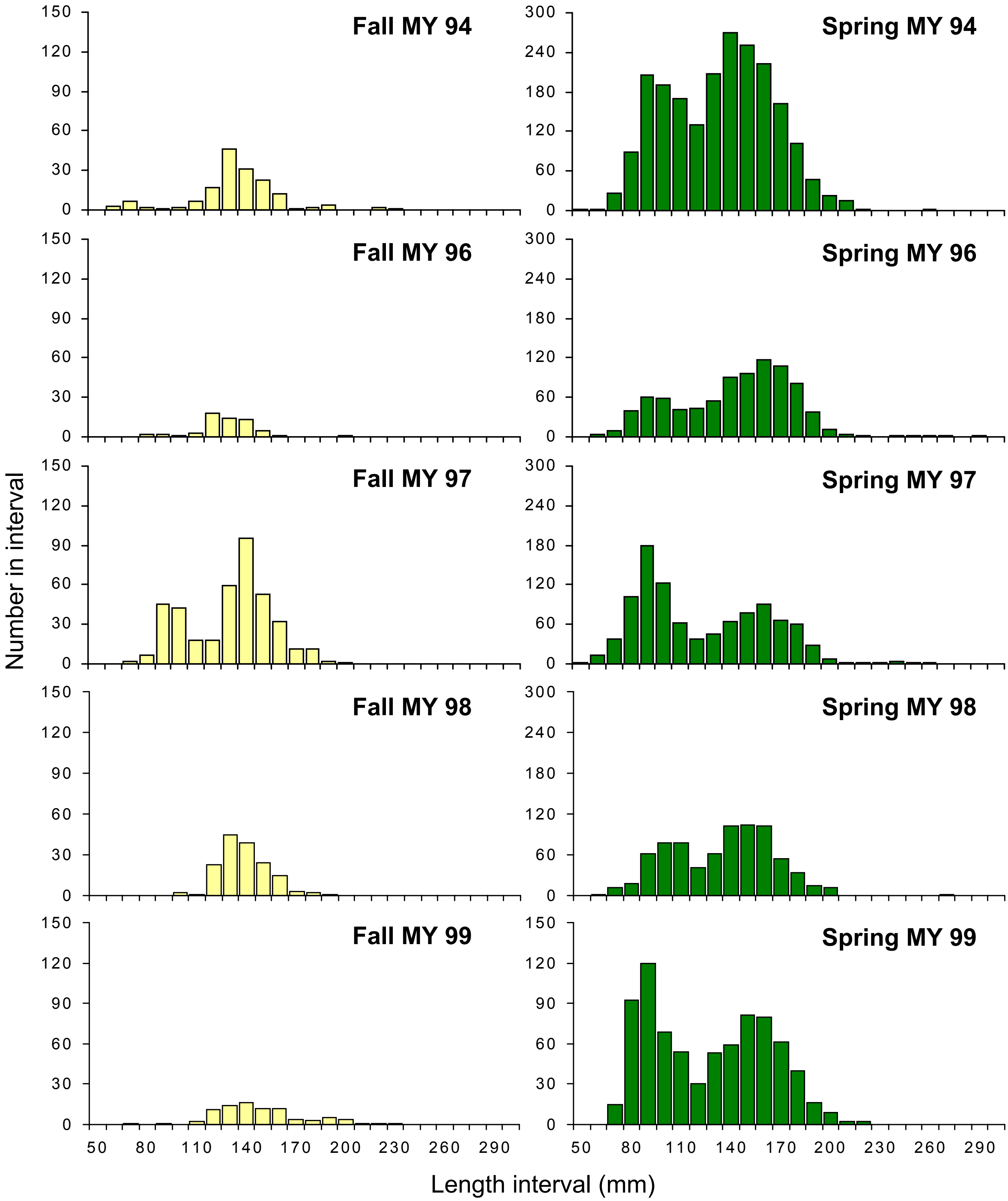

Figure 8. Length frequency distributions for *O. mykiss* captured at the Upper Grande Ronde River trap (rkm 3) by migration year.

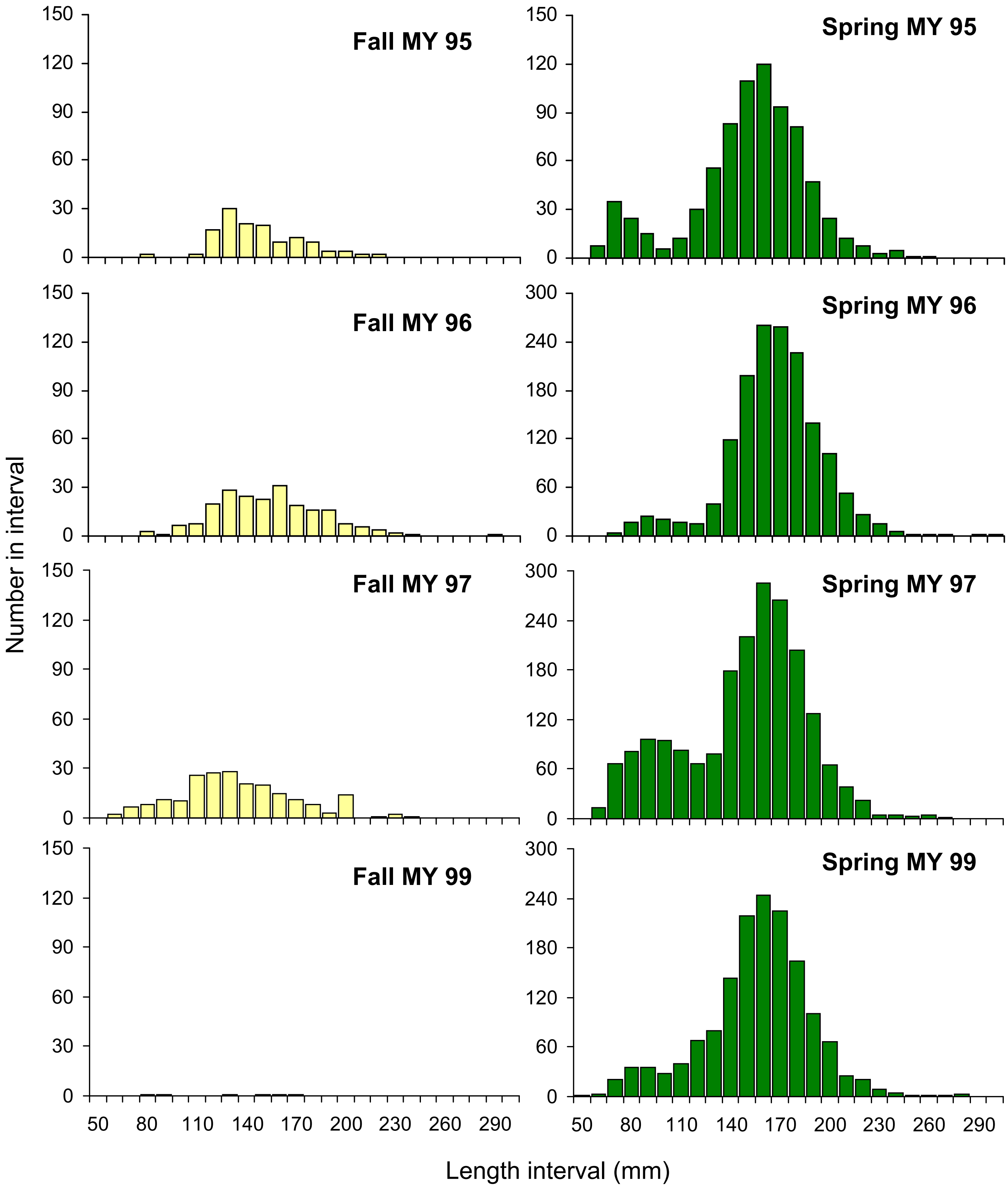

Figure 9. Length frequency distributions for *O. mykiss* captured at the Grande Ronde Valley trap (rkm 164) by migration year.

SUMMARY AND RECOMMENDATIONS

O. mykiss in the Grande Ronde basin exhibited directed downstream movements during fall, winter, and spring. The overall pattern of movement for *O. mykiss* is similar to that observed for spring chinook salmon (*O. tshawytscha)* (Keefe et al. 1998, Jonasson et al. 1997, Jonasson et al. 1996, Keefe et al. 1995, and Keefe et al. 1994). Both of these species move out of upper rearing areas in fall and spring of each migration year, with the majority of fish moving downstream in spring. Fall and winter movement appeared to be associated with changes in flow. Spring movement, although also synchronized with spring freshets, was elevated at all levels of flow. *O. mykiss* in the upper Grande Ronde basin begin to expand their rearing area during the fall of the year, but do not move below Grande Ronde Valley habitats until the spring of the year. This suggests that Grande Ronde Valley habitats act as more than a migration corridor to fish and should be managed as critical rearing habitat.

O. mykiss that originate from the Lostine River utilize a strategy similar to those observed in Catherine Creek. Lostine River fish expand their rearing area during the fall of the year, and rear somewhere below rkm 3 on the Lostine River. Although we suspect that these fish are using lower Wallowa River Valley and lower Grande Ronde River habitats as more than migration corridors, we were not able to verify this as we have done in the Grande Ronde Valley (above rkm 164).

Length frequency histograms of fish captured at Catherine Creek, Lostine and Upper Grande Ronde river trap sites show two distinct modes suggesting that fish in the upper river consist of distinct age classes which persist at all times of the year. Preliminary scale analysis for fish that moved downstream in fall from Catherine Creek and the upper Grande Ronde River was consistent with length frequency showing young of the year and age 1+ fish. Assuming that these fish are overwintering in Grande Ronde Valley habitats before migrating to the ocean the age distribution of spring migrating fish would include 1+ and older migrants. Since we did not collect scales from fish captured in the Grande Ronde Valley trap we were not able to identify the exact age of fish leaving the Grande Ronde Valley. We recommend collecting scales from *O. mykiss* throughout the year in order to better define the age distribution of migrants during all seasons.

We think that the Grande Ronde Valley trap (rkm 164) provides the best information on seaward migration of steelhead in the basin, because over 95% of the *O. mykiss* pass by the trap in the spring of each migration year, and length frequency distributions are characteristic of steelhead smolts. It may be possible to estimate the annual number of naturally produced steelhead leaving the Grande Ronde Valley using this trap if we were able to identify more concretely the number of steelhead that we catch here that are migrating seaward. We recommend continued marking of *O. mykiss* for trap efficiency tests so that we are able to estimate the number of fish passing each trap location.

We are unable to differentiate anadromous and resident *O. mykiss* at a juvenile stage when they co-occur. Given the decline in steelhead abundance and recent listing of Grande Ronde River populations, it would appear essential to obtain knowledge of ecological or reproductive relationships between the different life history forms of *O. mykiss* in the basin. Without such knowledge we can not effectively manage steelhead populations and achieve recovery goals. We will begin to explore the feasibility of different methodologies to differentiate the two forms of *O. mykiss* starting with analysis of body morphology (Beeman et al. 1994).

We know very little about the early life history of naturally produced steelhead in the Grande Ronde basin. To effectively manage steelhead populations, we need to improve our knowledge of life history and resolve the problem of differentiating anadromous from resident forms. We expanded the chinook early life history investigation in 1999 to include an investigation into steelhead life history strategies. We are focusing our efforts on tributary populations from the upper Grande Ronde River, Catherine Creek, and the Lostine River. In the first year of the investigation we are focusing on: documenting patterns of movement for juvenile *O. mykiss*, estimating and comparing smolt detection rates to mainstem Columbia and Snake river dams, evaluating methods of estimating seasonal migration tactics utilized by steelhead smolts, and beginning to describe population characteristics of juvenile *O. mykiss* in Catherine Creek.

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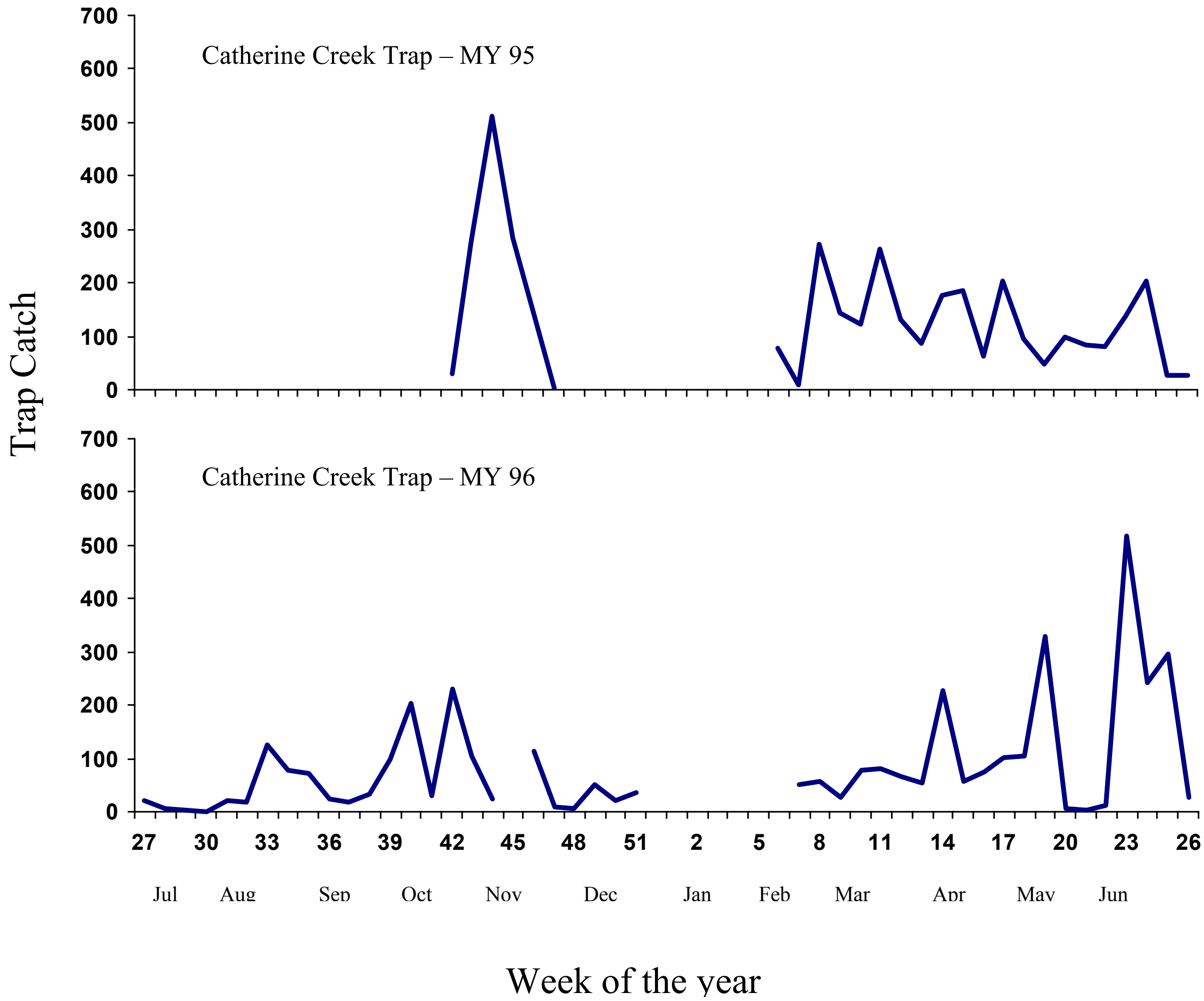
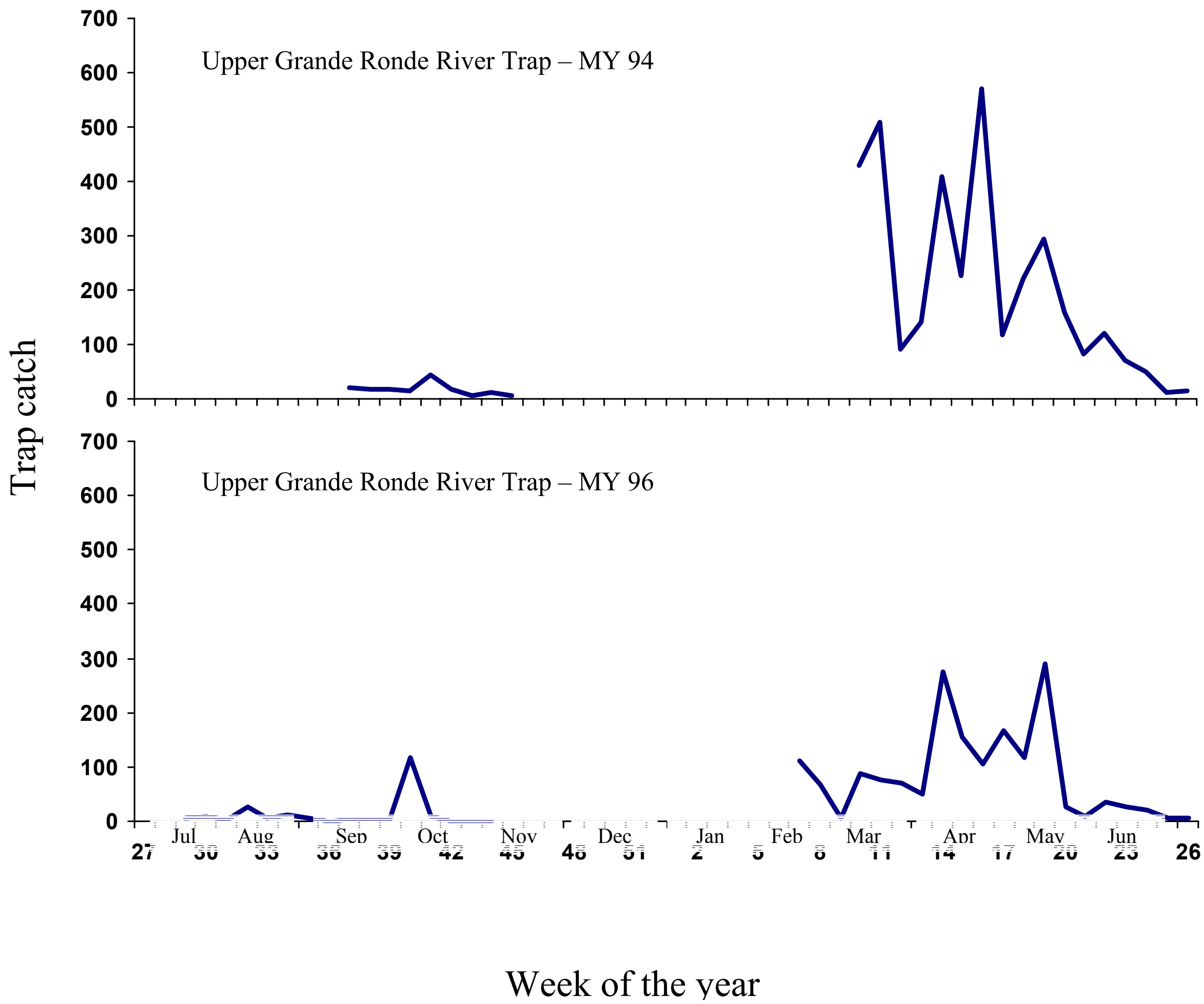
APPENDIX A

Catch Timing for Catherine Creek, Upper Grande Ronde River and Grande Ronde Valley Traps During Years When the Number of *O. mykiss* Moving Past the Traps Were not Estimated

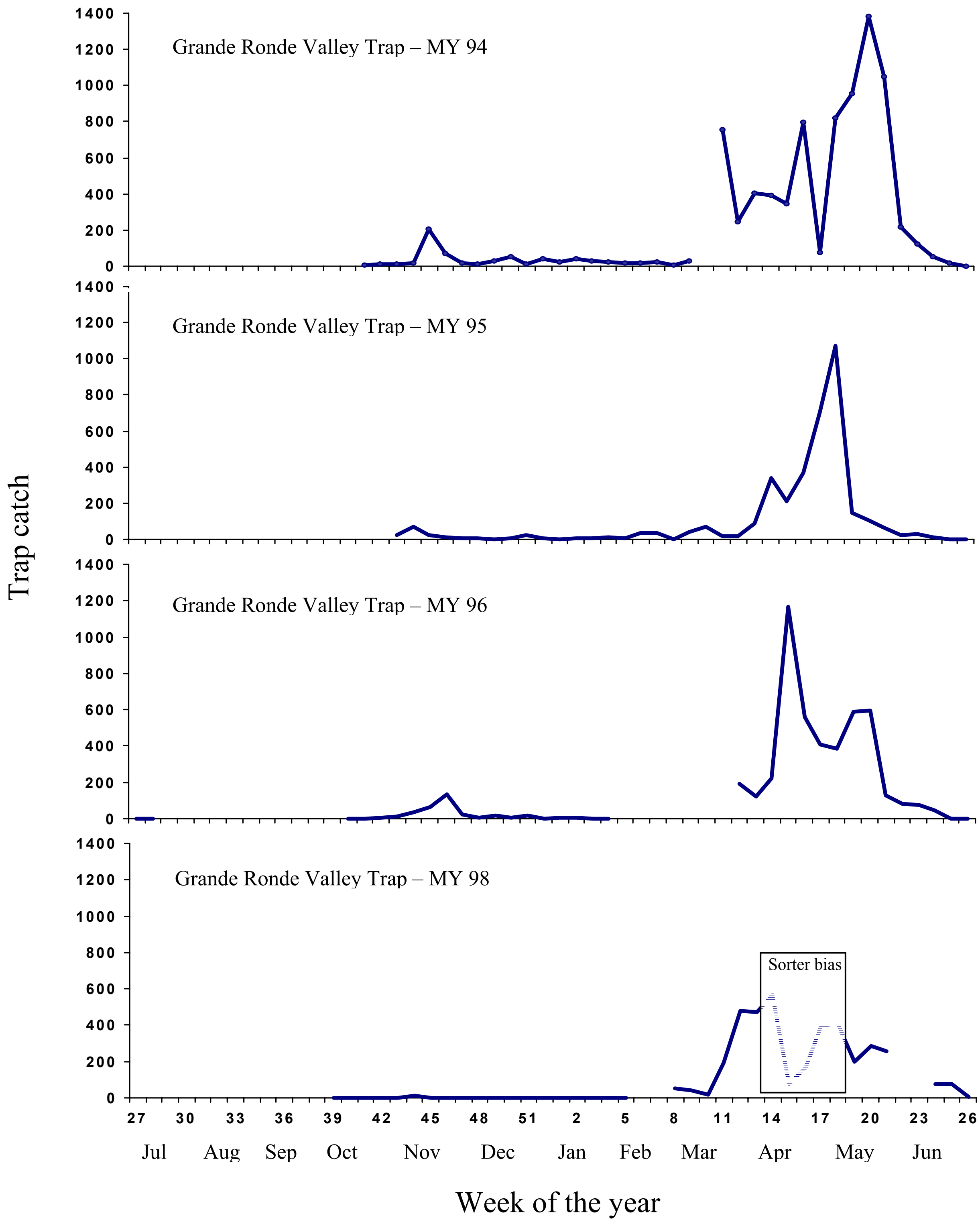
Appendix Figure A-1. Catch timing of *O. mykiss* past the Catherine Creek trap (rkm 32) for migration years 95 and 96 (MY). Periods when the trap was not fished for the entire week of the year are represented by a blank space.



Appendix Figure A-2. Catch timing of *O. mykiss* past the Upper Grande Ronde River trap (rkm 299) for migration years 94 and 96 (MY). Periods when the trap was not fished for the entire week of the year are represented by a blank space.



Appendix Figure A-3. Catch timing of *O. mykiss* past the Grande Ronde Valley trap (rkm 164) for migration years (MY) 95, 96 and 98. Periods when the trap was not fished for the entire week of the year are represented by a blank space. During MY 98 a sorter biased catch numbers collected during weeks 14 through 18 and only represents *O. mykiss* that passed through the sorter.



APPENDIX B

Julian Calendars

Appendix Table B-1. Julian calendar used for distinguishing time of movement by *O. mykiss* during non-leap years. Numbers in the shade cells represent julian weeks.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1	32	60	13	121	152	26	213	244	274	305	335
2	2	33	61	92	122	153	183	214	35	275	306	48
3	3	34	62	93	123	22	184	215	246	276	307	337
4	4	5	9	94	124	155	185	216	247	277	44	338
5	5	36	64	95	125	156	186	31	248	278	309	339
6	6	37	65	96	18	157	187	218	249	279	310	340
7	1	38	66	97	127	158	188	219	250	40	311	341
8	8	39	67	14	128	159	27	220	251	281	312	342
9	9	40	68	99	129	160	190	221	36	282	313	49
10	10	41	69	100	130	23	191	222	253	283	314	344
11	11	6	10	101	131	162	192	223	254	284	45	345
12	12	43	71	102	132	163	193	32	255	285	316	346
13	13	44	72	103	19	164	194	225	256	286	317	347
14	2	45	73	104	134	165	195	226	257	41	318	348
15	15	46	74	15	135	166	28	227	258	288	319	349
16	16	47	75	106	136	167	197	228	37	289	320	50
17	17	48	76	107	137	24	198	229	260	290	321	351
18	18	7	11	108	138	169	199	230	261	291	46	352
19	19	50	78	109	139	170	200	33	262	292	323	353
20	20	51	79	110	20	171	201	232	263	293	324	354
21	3	52	80	111	141	172	202	233	264	42	325	355
22	22	53	81	16	142	173	29	234	265	295	326	356
23	23	54	82	113	143	174	204	235	38	296	327	51
24	24	55	83	114	144	25	205	236	267	297	328	358
25	25	8	12	115	145	176	206	237	268	298	47	359
26	26	57	85	116	146	177	207	34	269	299	330	360
27	27	58	86	117	21	178	208	239	270	300	331	361
28	4	59	87	118	148	179	209	240	271	43	332	362
29	29		88	17	149	180	30	241	272	302	333	363
30	30		89	120	150	181	211	242	39	303	334	364
31	31		90		151		212	243		304		52

Appendix Table B-2. Julian calendar used for distinguishing time of movement by *O. mykiss* during leap years. Numbers in the shade cells represent julian weeks.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1	32	61	13	122	153	26	214	245	275	306	336
2	2	33	62	93	123	154	184	215	35	276	307	48
3	3	34	63	94	124	22	185	216	247	277	308	338
4	4	5	9	95	125	156	186	217	248	278	44	339
5	5	36	65	96	126	157	187	31	249	279	310	340
6	6	37	66	97	18	158	188	219	250	280	311	341
7	1	38	67	98	128	159	189	220	251	40	312	342
8	8	39	68	14	129	160	27	221	252	282	313	343
9	9	40	69	100	130	161	191	222	36	283	314	49
10	10	41	70	101	131	23	192	223	254	284	315	345
11	11	6	10	102	132	163	193	224	255	285	45	346
12	12	43	72	103	133	164	194	32	256	286	317	347
13	13	44	73	104	19	165	195	226	257	287	318	348
14	2	45	74	105	135	166	196	227	258	41	319	349
15	15	46	75	15	136	167	28	228	259	289	320	350
16	16	47	76	107	137	168	198	229	37	290	321	50
17	17	48	77	108	138	24	199	230	261	291	322	352
18	18	7	11	109	139	170	200	231	262	292	46	353
19	19	50	79	110	140	171	201	33	263	293	324	354
20	20	51	80	111	20	172	202	233	264	294	325	355
21	3	52	81	112	142	173	203	234	265	42	326	356
22	22	53	82	16	143	174	29	235	266	296	327	357
23	23	54	83	114	144	175	205	236	38	297	328	51
24	24	55	84	115	145	25	206	237	268	298	329	359
25	25	8	12	116	146	177	207	238	269	299	47	360
26	26	57	86	117	147	178	208	34	270	300	331	361
27	27	58	87	118	21	179	209	240	271	301	332	362
28	4	59	88	119	149	180	210	241	272	43	333	363
29	29	60	89	17	150	181	30	242	273	303	334	364
30	30		90	121	151	182	212	243	39	304	335	365
31	31		91		152		213	244		305		52